The characteristics of the transmission fiber which are relevant for the Raman amplification can have such a wide distribution from one sample to another, even for fibers of one type (SSMF, LEAF, TrueWave, ...), that there are detectable differences in the resulting gain spectrum. In addition, when the system is installed nothing is generally known about the insertion loss between the pumping source and the actual input to the transmission fiber. It is therefore only possible to set up a desired gain spectrum when the system is being commissioned if the actual gain spectrum which applies over each link section can be measured, and the pumping powers appropriately adjusted if there are deviations.

Until now there have been essentially four known methods for setting the pumping powers of the Raman sources when a system is being commissioned. The first method can be used if the system is commissioned with its maximum number of channels. In this case, the link sections are started up one after another, starting with the one immediately after the transmitter. As all the channels are already present during commissioning, they can be used as a test signal spectrum for a gain measurement. The signal spectrum at the output from the link section concerned is first measured with the Raman pumping source switched off, then the spectrum with the source switched on. The ratio of the two spectra, or the difference in the level in dB, as applicable, immediately gives the on/off gain spectrum of the Raman amplifier.

Unfortunately this method can seldom be used in practice, because most systems are commissioned using only a very small number of channels, and only later are they upgraded. It would indeed be possible in principle to measure and adjust the gain spectrum using only the signal channels already initially available, since the gain in the case of the channels which are still missing plays no part. It would then be necessary to remeasure and tune the gain spectrum before or during the commissioning of additional channels. The switching off of the Raman pumping source which this requires would

the specified fiber type for the transmission fiber. Since the method therefore has no knowledge of either the exact fiber characteristics or the insertion loss between the pumping source and the transmission fiber, the resulting gain spectrum can deviate significantly from that actually desired.

It is the object of the invention to specify a method, and in addition an arrangement, for the determination of the gain spectrum which enable the powers of the pumping sources for the Raman amplifier to be simply adjusted, and with which the disadvantages mentioned above are avoided.

This object is achieved, in respect of the method, by a method with the characteristics of Claim 1, and in respect of the device by an arrangement with the characteristics of Claim 7.

Advantageous developments of the invention are specified in the subclaims.

The proposed method in accordance with the invention uses as the test signal the amplified spontaneous emission, ASE, which is generated by the optical amplifiers present in the system, for example Erbium-doped fiber amplifiers, EDFAs. Since the fiber amplifiers, the EDFAs, must have a flat gain spectrum over the entire range of signal wavelengths, they will also generate ASE over the entire wavelength range, in that the gain spectrum of the distributed Raman amplifiers must be measured using a broadband pumping source. The ASE spectrum has a different graph from the gain spectrum of the EDFA fiber amplifiers. However, the exact shape of the ASE spectrum for the EDFA fiber amplifiers does not affect the measurement of the gain of the Raman amplifiers. The Raman gain spectrum which is to be measured is given by the ratio of spectra at the output from the link section with the Raman pumping source switched off or on, as applicable, and does not depend on the shape of the individual

Claims

1. Method for determining a gain spectrum (GS) for a Raman amplifier in a WDM transmission system, which is downstream from an optical amplifier,
characterized in that
with the optical amplifier and Raman amplifier active, the optical spectra (SPi) (i>1) of amplified spontaneous emissions (ASE) caused mainly by the optical amplifier are measured with the Raman amplifier switched off, and the gain spectrum (GS) is determined from these spectra (SPi).

2. Method in accordance with Claim 1
characterized in that
a first spectrum (SP1) is measured with the pumping source (PQ) for the Raman amplifier switched off and the pumping source for the optical amplifier switched on,
a third spectrum (SP3) is measured with the pumping source PQ for the Raman amplifier switched on and the pumping source for the optical amplifier switched on,
the gain spectrum (GS) for the Raman amplifier is calculated according to the following rule: $GS = \frac{SP3}{SP1}$.

3. Method in accordance with Claim 1
characterized in that
a first spectrum (SP1) is measured with the pumping source (PQ) for the Raman amplifier switched off and the pumping source for the optical amplifier switched on,
a second spectrum (SP2) is measured with the pumping source PQ for the Raman amplifier switched on and the pumping source for the optical amplifier switched off
a third spectrum (SP3) is measured with the pumping source PQ for the Raman amplifier switched on and the pumping source for the optical amplifier switched on,

the gain spectrum (GS) for the Raman amplifier is calculated according to the following rule: $GS = \frac{SP3 - SP2}{SP1}$.

4. Method in accordance with one of the Claims 1 to 3, characterized in that
for transmission links with additional optical amplifiers and additional Raman amplifiers, further spectra are measured by switching their pumping sources on and off, and from this the gain spectra of the Raman amplifiers are determined.

5. Method in accordance with one of the preceding claims, characterized in that
during the commissioning of a transmission link with several sections, which contain at least one optical amplifier and one Raman amplifier, the determination of the gain spectra (GS) is carried out section by section.

6. Method in accordance with one of the preceding claims, characterized in that
for the purpose of determining the gain spectrum (GS) the channel signals are attenuated so that a high level of amplified spontaneous emission (ASE) arises at the output of the optical amplifier.

7. Arrangement for determining/measuring the gain spectrum (GS) of a Raman amplifier in a WDM transmission system, which is downstream from an optical amplifier,
characterized in that
the arrangement contains an optical spectrum analyzer (OSA) and a control device (SE) for switching on and off the pumping sources for the optical amplifier and Raman amplifier,
upstream from the optical amplifier is an attenuation device (VOA) which, during a measurement, suppresses the channel signals (S1) so that the Raman amplifier is fed with a signal containing a high level of amplified spontaneous emission (ASE).

8. Arrangement in accordance with Claim 7, characterized in that connected to the optical spectrum analyzer (OSA) are a unit (EE) for analyzing the spectra recorded by the optical spectrum analyzer (OSA) and a regulator (RE) for controlling the spectral power components of the pumping source (PQ).

9. Arrangement in accordance with Claim 7 or 8, characterized in that the optical amplifier provided is a fiber amplifier (EDFA1, EDFA2, ...), a semiconductor amplifier or a discrete Raman amplifier.